Variable frequency drives and the use of Bypasses

White paper

File No: 100.2012
Date: OCTOBER 12, 2023
Supersedes: 100.2012
Date: SEPTEMBER 29, 2023

ABSTRACT

An efficient and effective way to reduce energy consumption is to allow motors to operate at lower speeds through the use of variable frequency drives (VFDs).

In the early days of VFD technology development, the bypass to a VFD was introduced to address reliability issues.

VFD technology and reliability has since improved dramatically. Is a bypass needed today? This bulletin will explore traditional solutions vs. newer solutions that require less space, are more energy efficient and reduce cost.

TRADITIONAL SOLUTION

A traditional bypass serves as a separate motor starter, mechanically linked to a companion VFD such that only the bypass or the VFD can operate the motor at any given time. Traditional bypasses require a **manual** operation to be engaged. Alternatively, 2- or 3-contactor variations **(FIG 1)** of traditional bypasses are also available. A 3-contactor bypass adds an extra contactor or a VFD isolation switch. While the application is running in bypass mode, an electrician can safely remove the VFD.

MODERN SOLUTION

Counter to the designs for a traditional bypass, there are updated solutions that offer appropriate redundancy, as well as lower installed cost, and improved system efficiency.

- **A** Conventional duty/standby (100%/100%) equipment **(FIG 2 & 4)**
- **B** Duty/duty (Lead/lag) equipment design **(FIG 3 & 5)**
- **C** N+1 equipment design
- **D** Redundant VFDs

Modern VFDs are more reliable, with an expected service life of 10-20 years, MTBF of 87,000 hours.

In non-critical applications, a bypass is not usually required. In these applications, a simple disconnect switch may be a viable solution to make replacement easier and safer in the event of a VFD failure.

Redundant VFDs are another option. In this design, a standby VFD will automatically provide control and protection if the primary VFD malfunctions. Purchasing a spare VFD to keep on hand is another option.

FIG 1

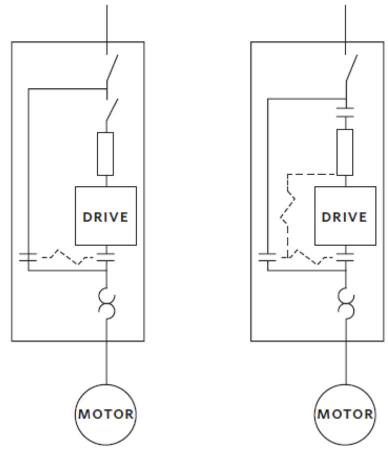


FIG 2. 2-PIPE 2-100% DUTY/STANDBY

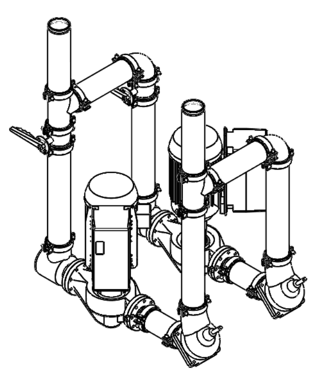


FIG 3. 1-PIPE 2-50% TO 2-100% PARALLEL PUMPING

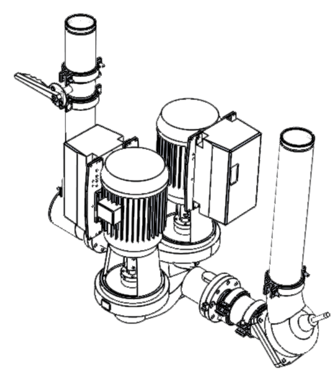


FIG 4. 2-PIPE 2-100% DUTY/STANDBY

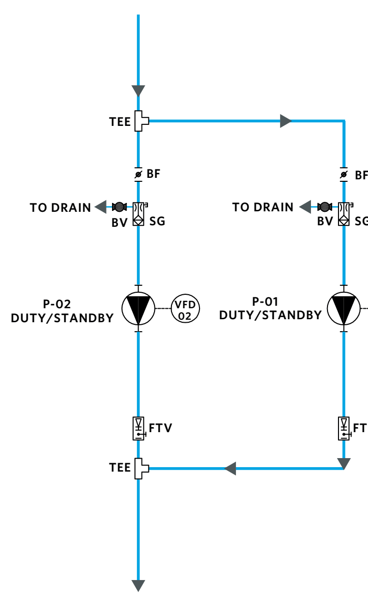
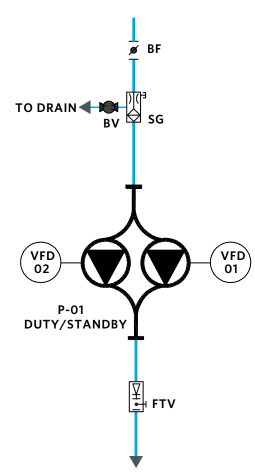


FIG 5. 2-50% TO 2-100% PARALLEL PUMPING



New motor technologies are more widely used in current pumping systems, providing higher efficiency levels and reducing energy consumption. For example, synchronous reluctance motors (Synch RM) and permanent magnet (PM) motors provide efficiencies (IE5/NEMA ultra-premium) that are 2 levels above standard IE3/NEMA Premium induction motors. These PM motors can only operate with a VFD. PM motors require soft-start capability to avoid damage. Across-the line starters/soft starters, used in bypasses, are not compatible with these high efficiency motors.

A list of the disadvantages of including a bypass in a system includes the following:

- **A** Using a bypass, sometimes requires pump selections with higher motor power (more expensive and less efficient)
- **B** A traditional bypass does not provide advanced motor protection. It requires relays for automatic control and does not have soft start capabilities.
- **C** In-Rush currents can be up to 600% of Full Load Amps (fla), also referred as lra (locked rotor current) and 200% of rated torque. This causes mechanical stresses to the windings and mechanical structure of the motor and can lead to significant heating of the motor windings. In larger motors, this heating limits the number of starts per hour allowed.
- **D** Circuit breakers must be sized accordingly, and appropriate electrical components are mandatory. In bypass situations, the main process control and the energy savings of the VFD are lost.
- **E** PM motors are increasingly preferred in pump applications due to their potential for up to 12% higher efficiency and significantly reduced weight, often half that of induction motors. However, using a bypass with a PM motor is constrained as it requires a VFD (Variable Frequency Drive) for operation.
- **F** A significant number of selections operate above 60 Hz for overspeed operation. In such instances, utilizing a bypass will cause the system to fall short of flow and head requirements. This drawback is particularly significant in chiller applications, where exceeding the published minimum or maximum flow rates due to a bypass can lead to severe damage.

CONCLUSION

With advancements in VFD capabilities and embedded control technology, there are disadvantages to using bypasses as a measure for handling redundancy. Designing systems to include VFD bypasses leads to oversized motors and drives, higher energy costs and higher first costs. Where modern VFDs are more reliable, for HVAC applications, the VFD bypasses are no longer needed. Armstrong does not recommend the use of VFD bypasses with Design Envelope pumping units.

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